Final Report

ECONOMIC ANALYSIS OF TOTAL WEED POPULATION MANAGEMENT FOR IRRIGATED AGRICULTURE

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In 1975 a six-year experiment was initiated to identify the impacts and differences of two weed management systems for eastern Colorado irrigated agriculture. The experiment focused upon two cropping systems: (1) an irrigated continuous corn monoculture and (2) an irrigated barley-corn silage-sugarbeet rotation.

The first weed management system (System I) is a typical set of weed management practices currently used by farmers. The second weed management system (System II) is a potentially adoptable set of weed management practices designed to make intensive use of chemical herbicides. The herbicides used under both systems for the two cropping systems are presented in Table 1. In general, System II includes both more herbicides and greater quantities of product when compared to System I.

Statistical analysis of the agronomic data by Schweizer and Zimdahl showed that the yield levels for the two weed management systems are not statistically different. An economic analysis of the same experimental data is the focus of this report. The objectives of the report are: (1) to present cost and return budgets for the crops under both weed management systems and (2) to evaluate the weed management systems under alternative input and product prices.

The economic analysis of this experiment is based upon comparative enterprise budgets. The variable costs and returns for System I and

Table 1. Herbicide Use in the Standard (System I) and Intensive System (System II) Weed Management Programs for Continuous Corn and a Barley-Corn Silage-Sugarbeet Rotation.

	Weed Management System	
	Standard Herbicide Program	Intensive Herbicide Program
Cropping System	(System I)	(System II)
Continuous Corn Grain	2.0#/Ac Atrazine[a]	1.5#/Ac Atrazine[a] 2.0#/Ac Alachlor[a] 0.5#/Ac 2,4-D[b]
Rotational Barley	0.5#/Ac 2,4-D[b]	0.5#/Ac 2,4-D[b] 0.25#/Ac Dicamba[b]
Corn Silage	3.0#/Ac Alachlor[a] 0.5#/Ac 2,4-D[b]	2.0#/Ac Alachlor[a] 1.5#/Ac Cyanazine[a] 0.5#/Ac 2,4-D[b] 0.25#/Ac Dicamba[b]
Sugarbeets	3.0#/Ac Cycloate[a] 0.5#/Ac Desmedipham[b] 0.5#/Ac Phenmedipham[b]	2.5#/Ac Ethofumesate[a] 0.5#/Ac Desmedipham[b] 0.5#/Ac Phenmedipham[b] 0.5#/Ac Trifluralin[b]

[a]Preemergence application.

[b]Postemergence application.

System II are developed and then compared. Because different weed control practices are used, the variable costs for the two systems will depend upon the herbicide cost, cost of herbicide application and other crop operations. Both the quantity of product produced and its quality are considered in the development of crop returns. Under the rotation, net returns are computed by crop and then aggregated over the set of crops in the rotation.

The impacts of changes in the prices of herbicides and crops will be considered in the analysis. Alternative herbicide costs and crop prices will give the analysis a price sensitivity dimension.

The analysis will first present assumptions used in the analysis regarding product prices, input prices and input quantities. The budgets and economic analysis for the continuous corn cropping system will then be presented followed by the crop rotation budgets and economic analysis. The report will conclude with a sections presenting the statistical significance and conclusions of the economic analysis.

ASSUMPTIONS

The analysis is made using the following base product prices: $2.60 per bushel for corn grain, $18.00 per ton for corn silage, $2.30 per bushel for barley and $28.00 per ton for sugarbeets with 16.5 percent sucrose.

Variable production costs are estimated using typical sequences of operations, a six row complement of machinery, the input quantities used in the field experiments and 1980 input prices. Repair costs, fuel and lubrication requirements are based upon American Society of Agricultural

Engineering machinery management data. Irrigation costs are based upon the average annual number of irrigations delivered in the experiment and reflect the costs and labor requirements given in the Firm Enterprise Data System (FEDS) budgets for Colorado ditch irrigation. Fuel is priced at $1.00 per gallon for diesel and $1.25 per gallon for gasoline. Labor is priced at $3.50 per hour and interest on operating capital is 16 percent for the months between planting and harvest, or in the case of sugarbeets, planting and receipt of first payment.

If product prices and herbicide costs are both expressed as indices, increasing and decreasing both indices by 50 percent is equivalent to varying the factor-product price index ratio between 33 and 300. This factor product price index ratio range includes nearly all of the ratios that existed during the life of the experiment. Factor-product price index ratios for all crops for each year of the experiment are presented in Table 2.

Changes in crop prices and the cost of herbicides and their application are critical in comparing the profitability of the two weed management systems. The price sensitivity analysis of this report will consider three product price levels and three herbicide cost levels. The levels are 50, 100 and 150 percent of the base product prices and 50, 100 and 150 percent of the 1980 herbicide costs. Thus nine combinations of product and herbicide prices are considered in the price sensitivity analysis.

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Table 2. Crop Price and Herbicide Cost Indices and Ratios.

		1975	1976	1977	1978	1979	1980
Crop Price Indices							
Corn Grain ($2.60/bushel=100)		100.8	81.9	74.6	86.9	97.3	117.3
Corn Silage ($18.00/ton=100)		108.3	100.0	83.3	86.1	100.0	116.7
Barley ($2.30/bushel=100)		114.8	94.3	102.2	100.4	103.9	123.9
Sugarbeets ($28.00/ton=100)		102.5	75.4	93.9	98.6	121.8	176.1
Herbicide Cost Indices (1980=100)							
Corn Grain	System I	153.8	139.2	153.3	150.0	121.7	100.0
	System II	99.5	112.5	105.7	118.2	101.8	100.0
Corn Silage	System I	a	104.0	90.7	84.5	88.6	100.0
	System II	79.5	100.5	94.4	85.6	95.9	100.0
Barley	System I	195.2	93.6	70.4	b	54.4	100.0
	System II	340.0	48.8	120.0	b	115.8	100.0
Sugarbeets	System I	120.3	139.8	147.4	99.3	93.0	100.0
	System II	128.8	77.7	89.5	82.2	79.7	100.0
Herbicide Cost-Crop Price Index Ratios							
Corn Grain	System I	152.6	170.1	205.5	172.5	125.1	85.3
	System II	98.7	137.4	141.7	136.0	104.6	85.3
Corn Silage	System I	a	104.0	108.9	98.1	88.6	85.7
	System II	73.4	100.5	113.3	99.4	95.9	85.7
Barley	System I	170.0	99.3[a]	68.9	b	52.4	80.7
	System II	296.2[c]	51.7[a]	117.4	b	111.5	80.7
Sugarbeets	System I	117.4	185.4	157.0	100.7	76.4	56.8
	System II	125.7	103.1	95.3	83.4	65.4	56.8

[a]Only 2,4-D was applied.

[b]No herbicide was applied because of a wet spring.

[c]Includes Fargo at $5.72 per acre.

CONTINUOUS CORN CROPPING SYSTEM

The continuous corn grain yields under the two weed management systems are nearly equal. As shown in Table 3, the standard weed management system average is 126.59 bushels per acre while the intensive weed management system had an average yield of 127.30 bushels per acre. Based on a corn price of $2.60 per bushel, the average gross revenues are $329.13 and $330.98 for Systems I and II. Thus, the intensive weed management system has an average gross revenue of only $1.79 more than the standard weed management system.

Based on 1980 prices, System I has variable costs of $178.55 compared to $188.03 for System II. Most of the $9.48 difference is attributed to the higher herbicide costs. Thus, the standard weed management system has an average return above variable costs advantage of $7.63 per acre because the System I's cost saving is greater than the value of the additional output under System II.

The average annual yields, gross revenues and return above variable costs by weed management system and the return above variable costs advantage of System I are presented in Table 4. Data are presented for both the years 1975 through 1980 and the average for the experiment.

In four of the six years, System I showed a positive net revenue advantage. The return above variable costs advantage of System I ranged from a negative $6.56 in 1976 (an advantage for System II) to $25.34. System I was not always the more profitable weed management system but was better two-thirds of the time and more profitable on average.

Table 3. 1980 Enterprise Budgets for Continuous Corn Grain for Eastern Colorado for a Standard (System I) and an Intensive (System II) Weed Management Systems.

Item	System I	System II
Revenue		
Yield (Bu/Ac)	126.59	127.30
Price ($/Bu)	2.60	2.60
Gross Revenue ($/Ac)	329.13	330.98
Variable Costs		
Fuel and Lube ($/Ac)	26.80	26.80
Repairs "	16.52	16.52
Seed "	21.00	21.00
Fertilizer "	63.00	63.00
Insecticide "	18.42	18.42
Herbicide "	4.24	12.08
Labor "	15.96	16.28
Interest "	13.23	13.93
Total: "	178.55	188.03
Return Above Variable Costs ($/Ac)	150.58	142.95
Return Above Variable Costs Advantage of System I ($/Ac)	7.63	

Table 4. Continuous Corn Grain Yield, Gross Revenue and Return Above Variable Costs (RAVC) by Weed Management System and the Return Above Variable Costs Advantage of the Standard Weed Management System (System I).

	Standard Weed Management System[a]			Intensive Weed Management System[b]			RAVC Advantage
	Yield	Gross Revenue	RAVC	Yield	Gross Revenue	RAVC	of System I
Year	(Bu/Ac)	($/Ac)	($/Ac)	(Bu/Ac)	($/Ac)	($/Ac)	($/Ac)
1975	112.08	291.44	112.86	110.38	286.99	98.96	13.90
1976	144.97	376.92	198.37	151.14	392.96	204.93	(6.56)
1977	137.66	357.92	179.37	141.46	367.80	179.77	(0.40)
1978	117.33	305.06	126.51	118.07	306.98	118.95	7.56
1979	110.18	286.47	107.92	111.56	290.06	102.03	5.89
1980	137.30	356.98	178.43	131.20	341.12	153.09	25.34
Average[c]	126.59	329.19	150.58	127.30	330.98	142.95	7.63

[a]Gross revenue at $2.60 per bushel and variable costs of $178.55 per acre.

[b]Gross revenue at $2.60 per bushel and variable costs of $188.03 per acre.

[c]Differences are due to rounding.

Table 5 presents data showing changes in the return above variable costs advantage of System I for alternative corn prices and herbicide cost levels. Nine combinations are presented for mixes of low, medium and high corn prices and herbicide cost levels. The corn prices used are: $1.30, $2.60 and $3.90 per bushel. The herbicide cost levels are 50, 100 and 150 percent of the 1980 cost level.

Under all price and cost combinations System I shows an average return above variable costs advantage. The average return above variable costs advantage of System I ranges from $2.79 to $12.48 depending upon the corn price and the herbicide cost level used. The standard deviation (a measure of variation) of the return above variable costs advantage increases proportionately with increases in the corn price but is constant across all herbicide price levels for a given corn price. The standard deviations of the return above variable costs advantage range from $5.09 to $15.27 depending upon the price of corn.

Increases in the cost level of herbicides for a given corn price show an increase in the average return above variable costs advantage of System I. This reflects the lower herbicide cost of System I compared to System II. A fifty percent increase from the 1980 herbicide cost level will increase the average return above variable costs advantage of System I by $3.92. A fifty percent decrease in herbicide costs (from the 1980 cost level) will decrease the average return above variable costs advantage of System I by the same amount.

When corn prices are increased the average return above variable costs advantage of System I decreases for a given herbicide cost level. This

Table 5. Return Above Variable Costs Advantage for the Standard Weed Management System (System I), for Selected Corn Prices and Herbicide Cost Levels by Year.

	Returns Above Variable Costs Advantage of System I								
Corn Price ($/Bu)	1.30	1.30	1.30	2.60	2.60	2.60	3.90	3.90	3.90
Herbicide Cost (% of 1980)	50	100	150	50	100	150	50	100	150
Year	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)
1975	7.77	11.69	15.61	9.98	13.90	17.82	12.19	16.11	20.03
1976	(2.46)	1.46	5.38	(10.48)	(6.56)	(2.64)	(18.50)	(14.58)	(10.66)
1977	0.62	4.54	8.46	(4.32)	(0.40)	3.52	(9.26)	(5.34)	(1.42)
1978	4.60	8.52	12.44	3.64	7.56	11.48	2.67	6.59	10.51
1979	3.77	7.69	11.61	1.97	5.89	9.81	0.18	4.10	8.02
1980	13.49	17.41	21.33	21.42	25.34	29.26	29.35	33.27	37.19
Average[a]	4.64	8.56	12.48	3.71	7.63	11.55	2.79	6.71	10.63
Std Dev.	5.09	5.09	5.09	10.18	10.18	10.18	15.27	15.27	15.27

[a]Differences are due to rounding.

reflects the higher yield of System II. A fifty percent increase in the price of corn will decrease the average return above variable costs advantage of System I by nearly one dollar.

The highest average return above variable costs advantage of System I takes place with the highest herbicide cost level and the lowest corn price. Similarly, the greatest relative return above variable costs advantage of System II is with the lowest herbicide price levels and highest corn price.

BARLEY-CORN SILAGE-SUGARBEET ROTATION CROPPING SYSTEM

The second cropping system in the experiment is a barley-corn silage-sugarbeet rotation. The analysis will be presented by first considering each of the crops and then aggregating the three crops and considering it as a rotation.

Barley

Table 6 shows that System I has an average yield of 88.23 bushels per acre while System II produced 86.71 bushels per acre. At a base price of $2.30 per bushel the gross revenues are $202.93 for System I and $199.43 for System II, thus the 1.52 bushel higher yield generates $3.50 more gross revenue per acre.

System II has total variable costs of $66.30 per acre including $3.56 for herbicides. Consequently, System II has $2.46 per acre more variable costs because of the cost of the Dicamba application and the associated $0.15, of interest.

The return above variable costs for System I is $139.09 per acre compared to $133.13 per acre for System II. The return above variable

Table 6. 1980 Enterprise Budgets for Barley, Corn Silage and Sugarbeets for Eastern Colorado for a Standard (System I) and an Intensive (System II) Weed Management Systems.

Item	Rotational Barley		Rotational Corn Silage		Rotational Sugarbeets	
	System I	System II	System I	System II	System I	System II
Revenue						
Yield (Units/Ac)	88.23[a]	86.71[a]	16.362[b]	17.238[b]	22.985[c]	23.311[d]
Price ($/Unit)	2.30	2.30	18.00	18.00	29.90	29.30
Gross Revenue ($/Ac)	202.93	199.43	294.52	310.28	687.25	683.01
Variable Costs						
Fuel and Lube ($/Ac)	12.99	12.99	27.48	27.96	42.91	43.66
Repairs "	16.75	16.75	21.96	22.51	50.83	51.43
Seed "	8.08	8.08	23.00	23.00	11.70	11.70
Fertilizer "	12.50	12.50	63.00	63.00	42.09	42.09
Insecticide "	---	---	18.42	18.42	12.68	12.68
Herbicide "	1.25	3.56	4.24	14.39	24.52	39.43
Labor "	8.26	8.26	15.47	15.47	21.49	22.19
Beet Thinning "	---	---	---	---	35.00	35.00
Interest "	4.01	4.16	10.48	10.88	27.34	29.26
Total: "	63.84	66.30	184.05	195.63	268.56	287.44
Return Above Variable Costs ($/Ac)	139.09	133.13	110.47	114.65	418.69	395.57
Return Above Variable Cost Advantage for System I ($/Ac)	5.96		(4.18)		23.12	

[a]Bushels per acre.

[b]Tons per acre.

[c]Tons of 17.36 percent sucrose sugarbeets.

[d]Tons of 17.09 percent sucrose sugarbeets.

costs advantage is because System I has both higher yields and lower herbicide costs compared to System II.

Data for the six years of the experiment and the average for the six years for rotational barley are presented in Table 7. During the first three years of the experiment System II out yielded System I and the associated gross revenues and return above variable costs reflect these higher yields. The yields are sufficiently high at the base price of $2.30 per bushel that the return above variable costs advantage of System I is negative. The last three years showed higher yields for System I compared to System II and thus the return above variable costs advantage of System I was positive in 1978, 1979 and 1980. The return above variable costs averaged $5.96 per acre more under System I than System II.

Price sensitivity information for barley is presented in Table 8. Return above variable costs advantage of System I for barley prices of $1.15, $2.30 and $3.45 per bushel combined with herbicide cost levels of 50, 100 and 150 percent of the 1980 cost are shown. The average return above variable costs for all combinations favors System I and ranges from $2.98 to $8.94 per acre depending upon the combination selected.

In 1978, 1979 and 1980 all price and cost combinations favored System I. In 1977 all price and cost combinations favored System II while in the first two years of the experiment 11 of the 18 combinations favored System II.

Table 7. Barley Yield, Gross Revenue and Return Above Variable Costs (RAVC) by Weed Management System and the Return Above Variable Costs Advantage of the Standard Weed Management System (System I).

	Standard Weed Management System[a]			Intensive Weed Management System[b]			RAVC Advantage of System I
Year	Yield (Bu/Ac)	Gross Revenue ($/Ac)	RAVC ($/Ac)	Yield (Bu/Ac)	Gross Revenue ($/Ac)	RAVC ($/Ac)	($/Ac)
1975	101.72	233.96	170.12	103.10	237.83	170.83	(0.71)
1976	77.67	178.64	114.80	79.01	181.72	115.42	(0.62)
1977	75.28	173.14	109.30	81.67	287.84	121.54	(12.24)
1978	106.33	244.56	180.72	101.78	234.09	167.79	12.93
1979	77.35	177.91	114.07	66.95	153.99	87.69	26.38
1980	91.02	209.35	145.51	87.73	201.78	135.48	10.03
Average[c]	88.23	202.93	139.09	86.71	199.43	133.13	5.96

[a]Gross revenue at $2.30 per bushel and variable cost of $63.84 per acre.

[b]Gross revenue at $2.30 per bushel and variable cost of $66.30 per acre.

[c]Differences are due to rounding.

Table 8. Return Above Variable Costs Advantage of the Standard Weed Management System (System I) for Selected Barley and Herbicide Prices by Year.

	Net Revenue Advantage of System I								
Barley Price ($/Bu)	1.15	1.15	1.15	2.30	2.30	2.30	3.45	3.45	3.45
Herbicide Cost (% of 1980)	50	100	150	50	100	150	50	100	150
Year	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)
1975	(0.36)	0.87	2.10	(1.94)	(0.71)	0.52	(3.53)	(2.30)	(1.07)
1976	(0.31)	0.92	2.15	(1.85)	1.62	0.61	(3.39)	(2.16)	(0.93)
1977	(6.12)	(4.89)	(3.66)	(13.47)	(12.24)	(11.01)	(20.82)	(19.59)	(18.36)
1978	6.46	7.69	8.92	11.70	12.93	14.16	16.93	18.16	19.39
1979	13.19	14.42	15.65	25.15	26.38	27.61	37.11	38.34	39.57
1980	5.01	6.24	7.47	8.80	10.03	11.26	12.58	13.81	15.04
Average[a]	2.98	4.21	5.44	4.73	5.96	7.19	6.48	7.71	8.94
Std Dev.	6.13	6.13	6.13	12.26	12.26	12.26	18.38	18.38	18.38

[a]Differences are due to rounding.

In all years and for all barley prices higher herbicide costs relatively favor System I. Increases in barley prices favor the weed management system with the higher yield. Thus, during 1977 when System II out yielded System I higher barley prices were relatively advantageous for System II. The reverse is also true, however, in years when System I yields are higher than those for System II.

Corn Silage

The corn silage yield was nearly one ton greater under System II. As shown in Table 6, System I has an average production of 16.362 tons per acre while System II produced 17.238 tons. With a base price of $18.00 per ton, the average gross revenue from System I is $294.52 compared to $310.28 under System II or $15.76 greater for System II.

The variable costs for the two systems are $184.05 and $195.63 for Systems I and II, respectively. The higher costs of System II are the result of the application of additional herbicides (cyanazine and dicamba) and the associated herbicide application and interest costs. The herbicide cost differences between the two weed management systems accounts for $10.15 of the $11.58 of higher variable costs for System II. Average return above variable costs are $110.44 for System I and $114.65 for System II generating a negative $4.18 average return above variable costs advantage for System I or a System II advantage of $4.18.

Table 9 shows that only in 1975 is the return above variable costs greater for System I. In each of the last five years System II has a greater return above variable costs. Only in 1975 did System I yield more than System II and the value of the yield difference combined with

Table 9. Corn Silage Yield, Gross Revenue and Return Above Variable Costs (RAVC) by Weed Management System and the Return Above Variable Costs Advantage of the Standard Weed Management System (System I).

	Standard Weed Management System[a]			Intensive Weed Management System[b]			RAVC Advantage
Year	Yield (T/Ac)	Gross Revenue ($/Ac)	RAVC ($/Ac)	Yield (T/Ac)	Gross Revenue ($/Ac)	RAVC ($/Ac)	of System I ($/Ac)
1975	17.0800	307.44	123.39	16.4675	296.42	100.79	22.61
1976	19.0775	343.40	159.35	20.8200	374.76	179.13	(19.79)
1977	16.0050	288.09	104.04	17.0725	307.31	111.68	(7.63)
1978	19.5950	352.71	168.66	20.2575	364.64	169.01	(0.34)
1979	14.3225	257.81	73.76	15.8625	285.53	89.90	(16.14)
1980	12.0925	217.59	33.62	12.9475	233.06	37.42	(3.81)
Average[c]	16.3621	294.52	110.44	17.2379	310.28	114.65	(4.18)

[a]Gross revenue at $18.00 per ton and variable costs of $184.05 per acre.

[b]Gross revenue at $18.00 per ton and variable costs of $195.63 per acre.

[c]Differences are due to rounding.

lower variable costs provided System I with a positive return above variable costs advantage.

The return above variable costs advantage of System I for alternative corn silage prices and herbicide cost levels is presented in Table 10. Corn silage prices of $9.00, $18.00 and $27.00 per ton and herbicide cost levels of 50, 100 and 150 percent of the 1980 cost level are reported. Only at the $9.00 per ton corn silage price and 100 and 150 percent of the 1980 herbicide cost levels are the average returns above variable costs advantage of System I positive. For the other seven corn silage price and herbicide cost levels the analysis shows an advantage for System II. For the highest corn silage price and lowest herbicide cost level System II shows a $16.83 average return above variable costs advantage.

Higher herbicide cost levels relatively favor System I but higher corn silage prices favor System II in all cases except 1975 when System I out yielded System II.

Sugarbeets

The third crop in the rotation is sugarbeets. Table 6 presents the enterprise budgets for sugarbeets and shows that the intensive weed management system produced an average of 23.331 tons of beets per acre with an average sucrose content of 17.09 percent. The standard weed management system has a yield of 22.985 tons of beets per acre with a sucrose content of 17.36 percent.

The sugarbeet price per ton is dependent upon the sucrose content of the beets. Based on $28.00 per ton for 16.5 percent sucrose beets,

Table 10. Return Above Variable Costs Advantage for the Standard Weed Management System (System I) for Selected Corn Silage and Herbicide Prices by Year.

	Return Above Variable Costs Advantage of System I								
Corn Silage Price ($/T)	9.00	9.00	9.00	18.00	18.00	18.00	27.00	27.00	27.00
Herbicide Cost (% of 1980)	50	100	150	50	100	150	50	100	150
Year	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)
1975	12.33	17.09	21.85	17.85	22.61	27.37	23.36	28.12	32.88
1976	(8.86)	(4.10)	0.66	(24.55)	(19.79)	(15.03)	(40.23)	(35.47)	(30.71)
1977	(2.79)	1.97	6.73	(12.40)	(7.64)	(2.88)	(22.00)	(17.24)	(12.48)
1978	0.86	5.62	10.38	(5.11)	(0.35)	4.42	(11.07)	(6.31)	(1.55)
1979	(7.04)	(2.28)	2.48	(20.90)	(16.20)	(11.38)	(34.76)	(30.00)	(25.24)
1980	(0.88)	3.89	8.65	(8.57)	(3.81)	(0.95)	(16.27)	(11.51)	(6.75)
Average[a]	(1.06)	3.70	8.46	(8.95)	(4.18)	(0.57)	(16.83)	(12.07)	(7.31)
Std Dev.	6.86	6.86	6.86	13.73	13.73	13.73	20.59	20.59	20.59

[a]Differences are due to rounding.

the per ton price for alternative sucrose levels is given by equation (1).

-8.8325048 + 2.312545 percent sucrose = Price in $/Ton (1)

System I beets with 17.36 percent average sucrose have a price of $29.90 per ton and System II beets with 17.09 percent average sucrose are priced at $29.30 per ton.

The average gross revenue from System I is $687.25 compared to System II average gross revenue of $683.01 or a difference of $4.24. Thus the lower yield of System I is more than compensated for by the higher beet price because of the higher sucrose level.

The variable costs of System I are $268.56 compared to $287.44 for System II. Herbicide costs in System II are $14.91 higher than under System I and accounted for nearly 80 percent of the difference in variable costs.

The average return above variable costs favors System I with $4.24 higher gross revenue and $18.88 lower variable costs for a total advantage of $23.12. Table 11 shows that in five of the six years the return above variable costs of System I are positive. Only in 1980 does the analysis show System II with greater return above variable costs.

Table 12 reports the results of the price and cost sensitivity analysis. Sugarbeet prices of $14.00, $28.00 and $42.00 per ton for 16.5 percent sucrose are used in combination with 50, 100 and 150 percent of the 1980 herbicide cost level. On average, all of the price and cost combinations show an advantage for System I. The size of the advantage ranges from $11.56 to $34.69 depending upon the sugarbeet price and cost combination considered. The advantage for System I increases both as herbicide costs increase and when sugarbeet prices increase.

Table 11. Sugarbeet Yield, Gross Revenue and Return Above Variable Costs (RAVC) by Weed Management System and the Return Above Variable Costs Advantage of the Standard Weed Management System (System I).

	Standard Weed Management System[a]				Intensive Weed Management System[b]				RAVC Advantage
	Sucrose	Yield	Gross Revenue	RAVC	Sucrose	Yield	Gross Revenue	RAVC	of System I
Year	(%)	(T/Ac)	($/Ac)	($/Ac)	(%)	(T/Ac)	($/Ac)	($/Ac)	($/Ac)
1975	18.79	21.090	630.59	362.03	18.61	21.305	624.24	336.80	25.23
1976	18.41	24.905	774.66	476.10	18.08	25.025	733.23	445.79	30.31
1977	17.13	27.715	828.68	560.12	16.73	28.545	836.37	548.93	11.19
1978	15.66	19.345	578.42	309.86	15.50	18.720	548.50	261.06	48.80
1979	16.43	20.835	622.97	354.41	15.96	20.380	597.13	309.69	44.71
1980	17.74	24.020	718.20	449.64	17.64	25.890	758.58	471.14	(21.50)
Average[c]	17.36	22.985	687.25	418.69	17.09	23.311	683.01	395.57	23.12

[a]Gross revenue at $29.90 per ton and variable costs of $268.56.

[b]Gross revenue at $29.30 per ton and variable costs of $287.44.

[c]Differences are due to rounding.

Table 12. Return Above Variable Costs Advantage for the Standard Weed Management System (System I) for Selected Sugarbeet and Herbicide Prices by Year.

	Returns Above Variable Costs Advantage of System I								
Sugarbeet Price ($/T)[a]	14.00	14.00	14.00	28.00	28.00	28.00	42.00	42.00	42.00
Herbicide Cost (% of 1980)	50	100	150	50	100	150	50	100	150
Year	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)
1975	12.62	22.06	31.50	15.79	25.23	34.67	18.97	28.41	37.85
1976	15.15	24.59	34.03	20.87	30.31	39.75	26.58	36.02	45.46
1977	5.60	15.04	24.48	1.75	11.19	20.63	(2.10)	7.35	16.79
1978	24.40	33.84	43.28	39.36	48.80	52.24	54.32	63.76	73.20
1979	22.36	31.80	41.24	35.27	44.71	54.15	48.19	57.63	67.07
1980	(10.75)	(1.31)	8.13	(30.94)	(21.50)	(12.06)	(51.13)	(41.69)	(32.25)
Average[b]	11.56	21.00	30.44	13.68	23.12	32.56	15.81	25.25	34.69
Std Dev.	11.75	11.75	11.75	23.51	23.51	23.51	35.26	35.26	35.26

[a]For beets with 16.5 percent sucrose.

[b]Differences are due to rounding.

Barley, Corn Silage and Sugarbeets Aggregated

The individual crops in a rotation must be aggregated to analyze the crop rotation. Table 13 shows the aggregated crop rotation values by year for the set of base prices. The table is expressed in terms of a single acre of rotation, thus one-third of the acre is in each of the three crops. The average return above variable costs advantage of System I is $8.29 per acre indicating that the return above variable costs will be greater on average with System I. In two of the four years System II showed an advantage over System I but two-thirds of the time System I dominated.

Table 14 reports the impact of the price and cost sensitivity analysis for the rotation. Crop prices of 50, 100 and 150 percent of the base prices and 50, 100 and 150 percent of the 1980 herbicide cost levels are used to develop nine price and cost combinations. In all cases, the average return above variable costs showed an advantage for System I. The range of the return above variable costs advantage of System I is from $1.81 to $14.77. The advantage of System I increases when herbicide prices increase and declines when product prices are increased.

Table 13. Aggregate Gross Revenue and Return Above Variable Costs (RAVC) by Weed Management System and the Return Above Variable Costs Advantage of the Standard Weed Management System (System I) for the Barley-Corn Silage-Sugarbeet Rotation.

	Standard Weed Management System[a]		Intensive Weed Management System[a]		RAVC Advantage
	Gross Revenue	RAVC	Gross Revenue	RAVC	of System I
Year	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)
1975	390.66	218.51	386.16	202.81	15.70
1976	432.23	250.08	429.90	246.78	3.30
1977	429.97	257.82	477.17	260.72	(2.90)
1978	391.90	219.75	382.41	199.29	20.46
1979	352.90	180.75	345.55	262.43	18.32
1980	381.71	209.59	397.81	214.68	(5.09)
Average[b]	394.90	222.74	397.57	214.45	8.29

[a]Gross revenue at base prices and 1980 variable costs.

[b]Differences are due to rounding.

Table 14. Return Above Variable Costs Advantage for the Standard Weed Management System (System I) for Selected Rotation Crop Prices and Herbicide Cost Levels by Year Aggregated for all Rotation Crops.

	Returns Above Variable Costs Advantage of System I								
Crop Prices (%)[a]	50	50	50	100	100	100	150	150	150
Herbicide Cost (% of 1980)	50	100	150	50	100	150	50	100	150
Year	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)	($/Ac)
1975	8.19	13.33	18.48	10.56	15.70	20.85	12.93	18.07	23.21
1976	1.99	7.13	12.27	(1.85)	3.30	8.44	5.69	(0.54)	4.60
1977	(1.11)	4.03	9.18	(8.05)	(2.90)	2.24	(14.98)	(9.83)	(4.69)
1978	10.57	15.71	20.85	15.31	20.46	25.60	20.05	25.20	30.34
1979	9.50	14.64	19.78	13.17	18.32	23.45	16.84	21.98	27.13
1980	(2.21)	2.93	8.08	(10.24)	(5.09)	0.05	(19.28)	(13.14)	(7.99)
Average[b]	4.49	9.63	14.77	3.15	8.29	13.43	1.81	6.96	12.10
Std Dev.	5.14	5.15	5.14	10.27	10.27	10.27	15.40	15.40	15.40

[a]Percent of base prices: Barley $2.30/bu, Corn Silage $18.00/Ton and Sugarbeets $28.00/Ton for 16.5% sucrose.

[b]Differences are due to rounding.

STATISTICAL SIGNIFICANCE OF THE RETURN ABOVE VARIABLE COSTS DIFFERENCES BETWEEN SYSTEM I AND SYSTEM II

The results presented in the preceding section show differences between expected net returns associated with the two weed management systems. Within a given year and between years, however, the economic performance of a weed management system can vary considerably. Therefore, the statistical significance of the reported differences in returns above variable costs also needs to be investigated. This was done using a two-way analysis of variance model with net returns above variable costs serving as the dependent variable and treatment and year as the independent variables.

On all runs the overall model (with interaction) was highly significant, with the significance level based on an F statistic being .001 or less in each instance. The interaction between treatment and year, on the other hand, was insignificant in each instance with the significance level based on an F statistic exceeding .372 in all runs. This means that the significance of the two main effects, treatment and year, can be tested independently using an additive model that controls for both factors but excludes interaction.

On all runs the explanatory power of this additive model was statistically significant at the 0.16 level or better. Of the two main effects, between year variation was clearly the more significant. Its level of significance was .001 or less in all runs.

Of primary interest here, however, is the statistical significance of the treatment effects, since this indicates the significance of the

difference between returns associated with the two weed control systems after effects of between year variation have been removed. Significance levels for the treatment effect under alternative product price levels are presented in Table 15. Of particular interest is the way the significance levels vary as product prices change.

As the price of continuous corn grain increases from 50 to 150 percent of the base price level the significance level of the F statistic changes from .003 to .227. This indicates that at the 50 percent of base corn grain price the difference in returns above variable costs is highly significant. When the corn grain price increases, however, the value of the significance level coefficient also increases indicating that the difference in the returns above variable costs for the two weed management systems is statistically less significant.

The rotational corn silage data in Table 15 are interesting in that the significance level increases from .390 to .862 and then decreases to .604 for the 50, 100 and 150 percent product price levels. This suggests that near the 100 percent product price level the two weed management systems have equal returns above variable costs and that for both higher and lower product prices the returns above variable costs for the two weed management systems diverge from being equal.

Figure 1 shows the significance level of the F statistic for product prices from 25 to 200 percent of the base price level for continuous corn grain and rotational corn silage. The corn silage curve shows a peak between 75 and 100 percent of the base price with lower significance levels on either side of these price levels. The continuous corn grain

Table 15. F Statistic Significance Level for Return Above Variable Costs Difference Between System I and System II for Continuous Corn, and Rotational Barley, Corn Silage and Sugarbeets for Selected Price Levels.

	Crop Price Level (Percent of Base Price)		
Crop	50	100	150
Continuous Corn	.003	.097	.227
Rotational Barley	.359	.490	.539
Corn Silage	.390	.862	.604
Sugarbeets	.001	.066	.185

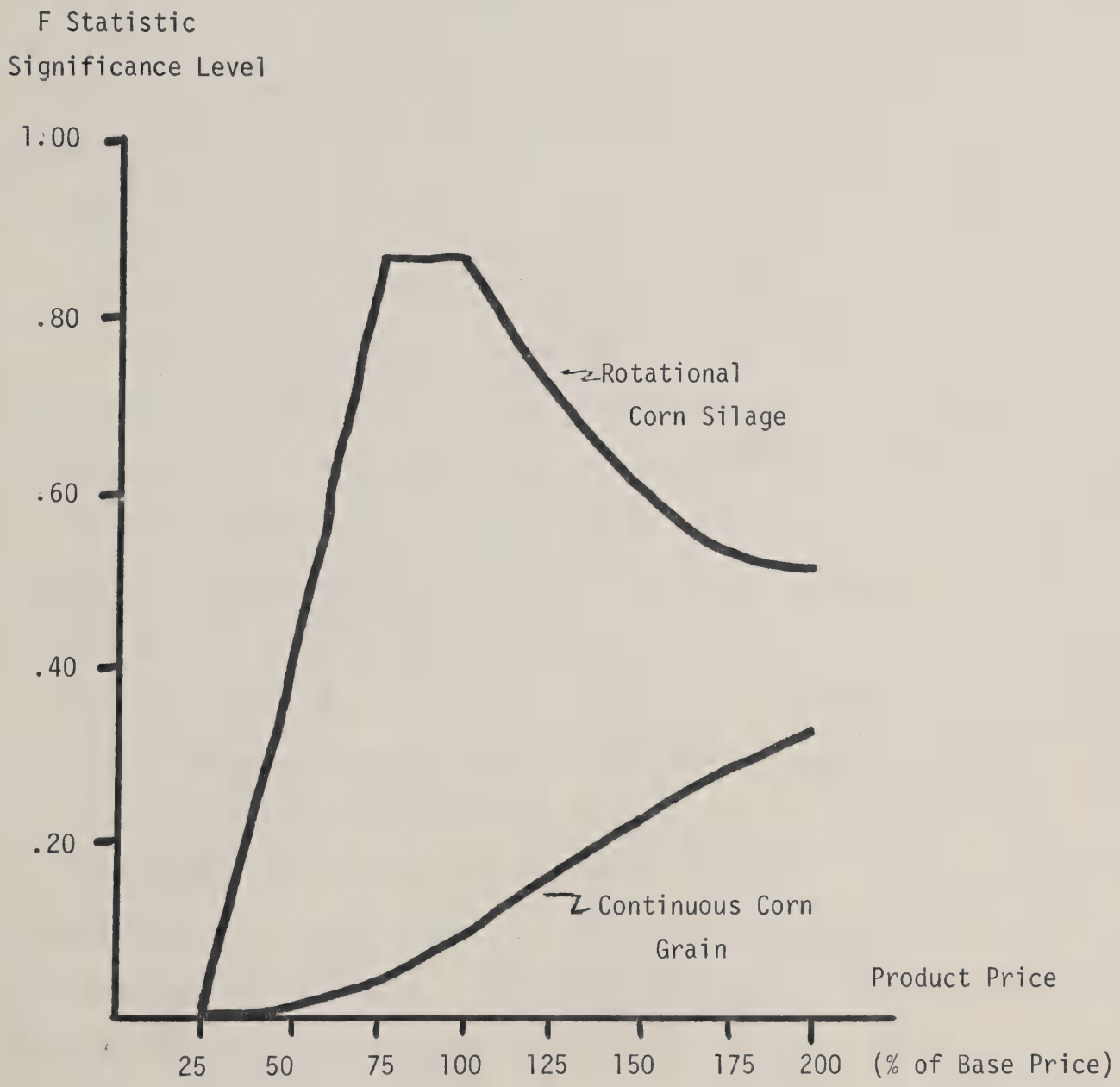
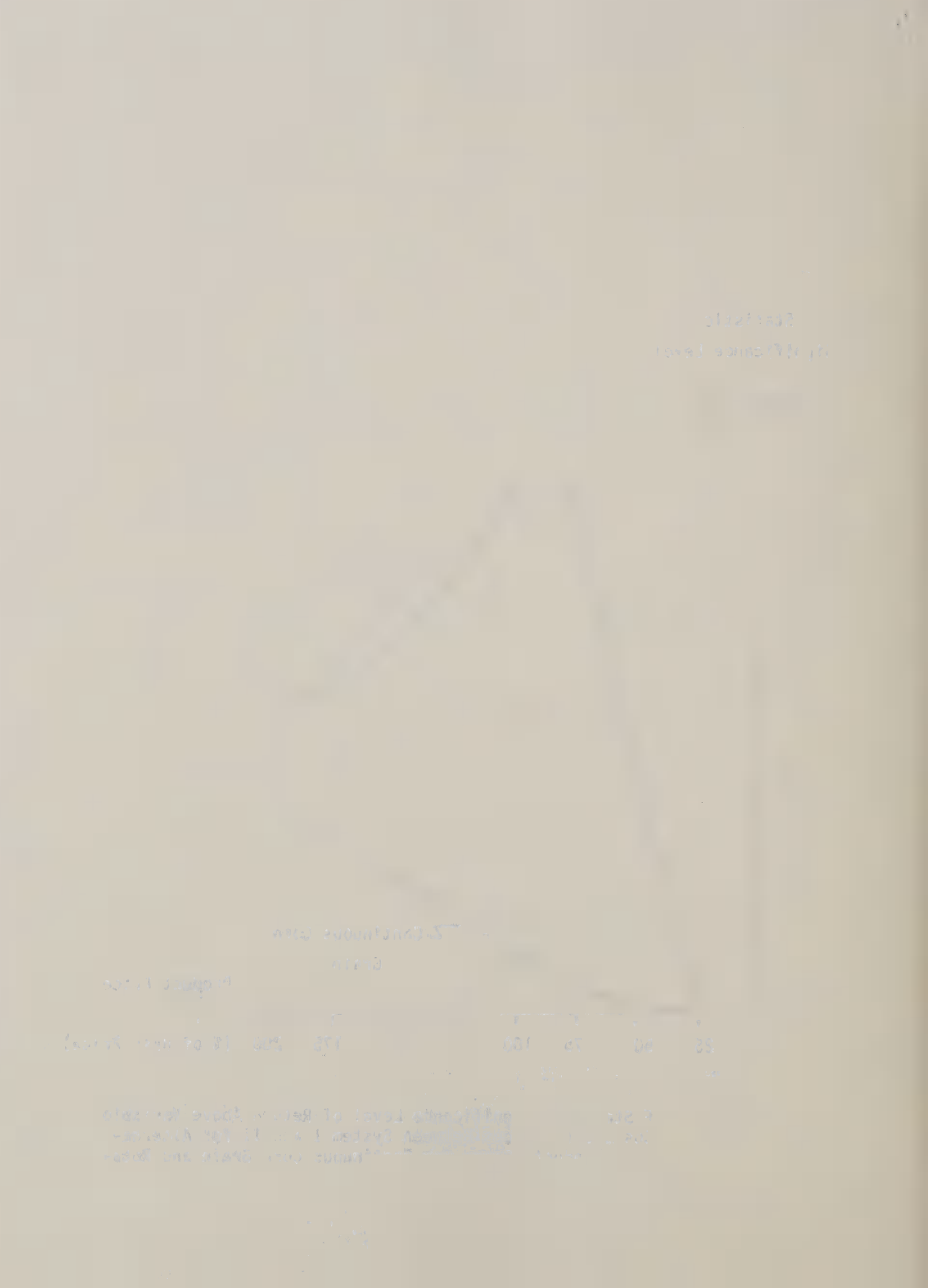


Figure 1. F Statistic Significance Level of Return Above Variable Costs Differences Between System I and II for Alternative Product Prices for Continuous Corn Grain and Rotational Corn Silage.



curve shows higher values of the F statistic significance level for higher product prices suggesting that product prices greater than 200 percent of the base product price level are necessary before the two weed management systems have equal returns above variable costs.

These results demonstrate that the statistical significance of economic and agronomic analysis may differ. The analysis also shows that economic recommendations can be quite sensitive to changes in the ratio of output and input prices.

SUMMARY AND CONCLUSIONS

A standard weed management system (System I) was shown to have a higher return above variable costs when compared to an intensive chemical weed management system (System II) for two cropping systems. The continuous corn cropping system had an average of $7.63 per acre greater return above variable costs under System I and the barley-corn silage-sugarbeets rotation averaged $8.29 per acre of rotation more under System I. The per acre return above variable costs advantage of System I is $5.96 for barley, a negative $4.18 for corn silage (showing an advantage for System II) and $23.12 for sugarbeets.

Both cropping systems have a higher return above variable costs for System I in four of the six years of the experiment using base level crop prices and 1980 variable costs. The average return above variable costs advantage of System I was positive for all nine combinations of low, medium and high product prices and herbicide cost levels for both cropping systems.

The higher return above variable costs for System I is not uniform for the crops in the rotation. For crop base prices and 1980 variable costs, System I has a higher return above variable costs three, one and five years out of six for the barley, corn silage and sugarbeets, respectively. The average return above variable costs for the alternative price and cost levels favored System I in all years for barley, sugarbeets and the aggregated rotation crops. For corn silage, however, System I has a higher return above variable costs in only two of the nine price and cost combinations examined.

Higher herbicide costs relatively favor the standard weed management system. Higher crop prices relatively favor the weed management system with the higher yields adjusted for quality.

Statistical analysis of the differences in the return above variable costs for the two weed management systems varies depending upon the level of product prices and herbicide costs used. For the crop base price levels and 1980 variable costs the differences in return above variable costs between the two weed management systems is significant at the 0.66 level for sugarbeets and .097 level for continuous corn grain. The other two crops showed a significance level of the F statistic at considerably higher values. At the 50 percent of crop base price level sugarbeets is significant at the .001 level and continuous corn at the .003 level.

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CRIS REPORT

Cost and return budgets were prepared for a standard weed management system (System I) and an intensive weed management system (System II) for a continuous corn and a barley-corn silage-sugarbeets rotation. Under base cost and price levels System I showed a $7.63 per acre return above variable costs advantage over System II for continuous corn. Under selected alternative corn price and herbicide cost levels the average return for System I showed an advantage of from $2.79 to $12.48 per acre.

Under base cost and product prices the rotational barley and sugarbeets showed an average advantage for System I of $5.96 and $23.12 per acre, respectively. The rotational corn silage, however, showed an average advantage for System II of $4.18 per acre. Average aggregate returns per acre for the rotation showed an advantage for System I of $8.29 per acre. Under selected product and herbicide price combinations all average aggregate rotation returns above variable costs favored System I but most rotational corn silage price combinations favored System II.

The statistical significance of the differences of the returns above variable costs between System I and II varies with the product-input price ratio. At the base price and cost levels, the F statistic significance levels for return above variable costs difference between System I and II were: continuous corn, .097; rotational barley, .490; rotational corn, .862; and rotational sugarbeets, .066. The results demonstrate that the statistical significance of economic and agronomic analysis may differ. Additional manuscripts are being drafted to document the research findings.

PUBLICATIONS:

King, R. P., Lybecker, D. W., Schweizer, E. E. and R. L. Zimdahl. "Weed Control Strategies Under Uncertainty." Amer. J. Agr. Econ. 62(1980), p. 1105 (Contributed Papers Abstract).